first rank *Holaster Dewalquei* of the Landenian system. This is the first time that the genus *Holaster*, so abundantly represented in the different stages of the Cretaceous formation, has been met with in the Tertiary. This species, although the last of the series, presents perfectly all the characters of the type; it is remarkable for its large size, its regularly cordiform aspect, its inflated and subgibbous upper surface, and its angular and very deep anterior groove. M. Manzoni has already noticed in the Tertiary of the environs of Bologna a species nearly allied to *Holaster Dewalquei*, but distinct, namely *Hemipneustes italicus*. We may also cite *Caratomus Lehoni* from the Laekenian of St. Gilles, a very curious species, differing from the true *Caratomi* by the structure of the anterior ambulacral areas and the form of the peristome. And we may mention *Echinus Colbeaui*, which we only know in the state of an interior cast, but which is distinguished from its congeners by its large size, its subconical form, its lower surface pulvinate and rounded at the margins, and by its peristome opening in a well-marked depression of the lower surface. Nor must we forget *Spatangus pes equuli*, peculiar to the Eocene of Belgium, and which will always be recognized with facility by its elevated hemispherical form, its flat lower surface with trenchant edges, and its very deep anterior groove with keeled margins.—*Comptes Rendus*, July 19, 1880, p. 182.

On the Antiquity of certain Subordinate Types of Freshwater and Land Mollusca. By C. A. White, Palæontologist to the U.S. National Museum.

Among existing freshwater and land Mollusca there are certain comprehensive genera which may be divided into a greater or less number of more or less distinctly definable groups that are respectively recognizable by certain common characteristics, less conspicuous than those which separate the larger genera from each other. These minor groups have been treated as genera, subgenera, or as still less important sections by the various authors who have discussed them, according to the individual estimate that has been placed upon the relative value of the characters by which they are recognized. It is my present purpose, not to discuss the value of these distinctions as means of zoological classification, but to show that a considerable number, not only of the larger genera of living North-American freshwater and land Mollusca, but also a large proportion of the minor or subordinate types which those genera respectively embrace, had their origin as such at least as early as the closing epochs of the Cretaceous or the immediately following epochs of the Eocene Tertiary period.

The fossil collections upon which these observations are based, and which alone are referred to in the following remarks, are those which have been obtained by the different U.S. Government Surveys in the western portion of our national domain. The strata which have furnished these fossils are, in the ascending order, those of the Fox Hills, Laramie, Wahsatch, Green River, and Bridger groups. The first-named of these groups is unquestionably Cretaceous; and

the last three are as unquestionably Eocene Tertiary. The second I regard as representing a transitional epoch; but some geologists assign it to the Cretaceous period, because of the presence of dinosaurian remains in its strata. Others refer it to the Tertiary, because of the characteristics of its floral remains. It is sufficient for my present purpose to say that the molluscan types here discussed are found in strata which range from the Cretaceous to the close of the Eocene inclusive.

The comprehensive genera that embrace the minor types which are here more especially discussed or referred to are *Limnæa*, *Planorbis*, *Physa*, *Helix*, *Pupa*, *Succinea*, and *Unio*. The minor types that may be mentioned as having representatives among the fossil collections already referred to are especially noticeable among the pulmonate Gasteropoda and the Unionidæ. The principal examples of the former are indicated by the following list of the names by which the types are known, and which have been applied to them by different authors in either a generic or subgeneric sense. These examples by no means represent, even approximately, the full molluscan faunas of which they form a part; but they are selected for the special purpose already indicated.

LIMNÆINÆ.

1. Acella, *Haldeman.*
2. Leptolimnæa, *Swainson.*
3. Limnophysa, *Fitzinger.*

PLANORBINÆ.

4. Planorbis (typical), *Guettard.*
5. Bathyomphalus, *Agassiz.*
6. Gyraulus, *Agassiz.*

PHYSINÆ.

7. Physa (typical), *Draparnaud.*
8. Bulinus, *Adanson.*

HELICINÆ.

9. Aglaia, *Albers.*
10. Arianta, *Leach.*
11. Patula, *Haldeman.*
12. Strobila, *Morse.*
13. Triodopsis, *Rafinesque.*

PUPINÆ.

14. Leucocheila, *Alb. & Mart.*
15. Pupilla, *Leach.*
16. Holospira ?, *Albers*.*

SUCCININÆ.

17. Brachyspira, *Pfeiffer.*

It should be mentioned that these subordinate types were originally recognized among, and their names applied wholly to, living forms. The discovery of fossil forms of those types is a gratifying confirmation of their genuineness (time being the crucial test of permanency), and proof of the sagacity of their authors.

Acella is represented by *A. Haldemani*, White †, from the Laramie strata of Bear-River valley, Wyoming. With the probable exception of an undescribed form in the Green-River strata of Wyoming, no other fossil species of that type is yet known; but the *Limnæa* (*Pleurolimnæa*) *tenuicostata* of Meek and Hayden, from the Laramie strata of Montana, is a closely allied form. *Limnæa* (*Leptolimnæa* ?) *minuscula*, White, from the Green-River strata of Wyoming, appears

* *Holospira* is placed here under the *Pupinæ* only conventionally.

† The species herein mentioned are described and in part figured in the following publications:—Annual Reports U S. Geol. Surv. Terr.; vol. ix. (4to ser.) of the same; Bulletin of the same; Powell's Rep. Geol. Uinta Mts.; U.S. Expl. and Surv. west of the 100th Merid., vol. iv.; U.S. Geol. Surv. 40th Parallel, vol. iv.; Simpson's Rep. Great Basin, Utah; and Proc. U.S. National Museum, vol. iii. (The latter now in press.)

to possess the characteristics of *Leptolimnæa*, Swainson. The earliest known species of *Limnophysa* is *L. nitidula*, Meek, which is associated with *Acella Haldemani*, just mentioned. Two other species from the Green-River group of Wyoming are referred to that type, namely *L. vetusta* and *L. similis*, Meek.

Planorbis proper is represented by *P. æqualis*, White, in the Green-River strata of Wyoming. *Bathyomphalus* has two representatives, namely *P.* (*B.*) *kanabensis*, White, and *P.* (*B.*) *planoconvexus*, Meek and Hayden; both in the Laramie group. The former comes from Southern Utah, and the latter from Montana. *Gyraulus* appears to have several representatives in both the Laramie and Green-River strata: but *G. militaris*, White, from strata probably of the Laramie period, is the only one yet published.

A considerable number of species of the Physinæ are known in the Laramie, Wahsatch, and Green-River groups; and the subfamily was well established before the first-named period. It is an interesting fact, in confirmation of the latter statement, that a typical species of *Physa*, *P. Carletoni*, Meek, has been found at Coalville, Utah, in estuary strata which rest upon marine Cretaceous strata, and have more than 1000 feet of similar marine Cretaceous strata resting upon them. This is the earliest *Physa* known in American strata. *Physa pleromatis*, White, is a widely distributed species in the Wahsatch group of Wyoming, Colorado, and Utah; but true *Physa* is not common in the Laramie group, although that genus prevailed both before and after. In the last-named group *Bulinus* is somewhat common—*B. atavus*, White, and *B. subelongatus*, Meek and Hayden, being published examples.

The Helicinæ appear to have been almost as diversely differentiated during the Laramie, Wahsatch, and Green-River epochs as they are at the present day, no less than five of the subordinate types embraced in that subfamily having been more or less satisfactorily recognized among the molluscan faunas of these epochs. *Aglaia* is represented by *Helix peripheria*, White, in the Green-River group of Utah; and *Arianta* by *H. riparia*, White, in the same group of Southern Wyoming. *Helix kanabensis*, White, seems to possess the distinguishing characteristics of *Strobila*. It occurs in the upper part of the Laramie group of Southern Utah. *Patula* is represented by *Helix sepulta*, White, in the coal-bearing strata of Evanston, Wyoming, which belong either to the upper part of the Laramie group or the base of the Wahsatch, probably the former; and apparently also by an undescribed species in the Green-River group of Wyoming. *Triodopsis* is represented by *Helix evanstonensis*, White, which is associated with *H. sepulta*, just mentioned.

The Pupinæ have been recognized only in the Green-River and Bridger groups, four species only having yet been discovered. The true character of the aperture has been ascertained only in one of these; and they are therefore assigned with some doubt to the types mentioned. Their diverse forms, however, indicate that a wide differentiation had taken place in the Pupinæ at that early time. *Pupa arenula* and *P. atavuncula*, White, discovered in the Green-River strata of Wyoming, are referred provisionally to *Pupilla*, and

an associated species, *Pupa incolata*, White, to *Leucocheila*. Mr. Meek referred his *Pupa Leidyi* doubtfully to *Holospira*. It is from the Bridger strata of Wyoming.

Only one species of the Succininæ has yet been discovered in any of the strata here considered, namely *Succinea papillispira* of the Green-River strata of Wyoming. This is plainly referable to *Brachyspira*.

The Unionidæ of the fossil molluscan fauna, herein discussed, are found to have become differentiated to a remarkable extent, especially during the Laramie epoch. An exceedingly interesting and suggestive fact in connexion with this differentiation is that the subordinate types are largely identical in character with some of those which are now living in the waters of the Mississippi river-system, and which are recognized by malacologists as distinctively North-American types. Illustrative of this relation of the fossil to the recent forms, the following parallel lists are presented, those of the left-hand column being a part of the fossil species now known in the Laramie strata of Wyoming and Utah, and those of the right-hand column being the living species of the Mississippi river-system which are selected as their respective type congeners.

Unio propheticus, *White.*	Unio clavus, *Lamarck.*
—— proavitus, *W.*	—— ridibundus, *Say.*
—— gonionotus, *W.*	—— multiplicatus, *Lea.*
—— holmesianus, *W.*	—— apiculatus, *Say.*
—— Couesi, *W.*	—— complanatus, *Solander.*
—— Endlichi, *W.*	—— gibbus, *Barnes.*
—— brachyopisthus, *W.*	—— circulus, *Lea.*

Still other examples might be given of close resemblances between fossil and recent forms of *Unio*; but these suffice to suggest in a very forcible manner that the Unionine fauna of the Mississippi river-system is genetically related to that of the Laramie period. It is true that in the Laramie fauna there are certain minor types of *Unio* which are not so closely like any living forms as those are which have been cited, and that close congeners of certain living types have not been discovered among the fossil forms; but these facts do not necessarily affect the legitimacy of the conclusion that the living has genetically descended from the fossil fauna. A like conclusion is also reached with reference to the pulmonate gasteropods, which have already been discussed; but in view of the magnitude of the physical changes which have taken place since the close of even the latest epoch here considered, the survival of the types of the branchiferous Mollusca, and their transference from lacustrine to fluviatile waters, is a most remarkable circumstance.

Reviewing the collections which represent the fossil faunas herein discussed, so many familiar forms are seen that it is difficult to realize the fact that a large proportion of them, including those especially which have been mentioned by name in this article, were living contemporaneously with the last of the Dinosaurs. Yet such is the fact, and the shells of the former are often found commingled with the bones of the latter. What were the successive steps in the history of the transmission of these types from that remote time to the present we are unfortunately without the means of knowing with certainty, because of the remarkable paucity of molluscan remains in all the deposits of the great interior region

later than the Eocene. All the molluscan remains which have been found in these later deposits belong to familiar living types, although of extinct species.

That the palustral and land pulmonates might have been, and perhaps were, preserved under immediate conditions differing from those which ensured the survival of the Unionidæ is evident; but certain facts point to the conclusion that the peculiar "North-American" types of *Uniones* which prevailed in the Laramie epoch were not transmitted through the Eocene, Miocene, and Pliocene epochs as denizens of the freshwater lakes which succeeded the brackish water of the Laramie sea, and each other, in their occupancy of a great part of the interior region of North America, up to at least near the close of the Pliocene epoch. The Eocene freshwater deposits contain a considerable number of species of *Unio*, it is true; but they are all, so far as known, of a smooth surface and oval form, and constitute a type which, although common among living *Uniones*, is exceedingly rare, if not entirely wanting, in the Laramie group. The conclusion therefore seems necessary that those peculiar and varied forms of *Unio* which have been mentioned in the preceding list, with their faunal molluscan associates, escaped from the Laramie lacustrine waters before the close of that epoch, into those fluviatile waters which form the outlet to the lacustrine, and which became a part of the Mississippi drainage-system as the elevation of the continent progressed*.

The magnitude of the physical changes which have taken place upon the North-American continent since the epochs in which the Mollusca lived, which are discussed in this article, has already been referred to. These changes were no less than the gradual desiccation of the region formerly occupied by great inland lakes, which for magnitude have now no equals upon the earth, the elevation of the whole Rocky-Mountain system, and the establishment of the present great interior river-systems. Through all these changes these molluscan types have come down to us in unbroken lines, some of which, to speak figuratively, were of remarkable tenuity. It is true there has been a dropping out of some of the earlier associated types and an introduction of new ones as the epochs passed; but the lines of descent of the numerous types which have reached us unbroken seem to be almost parallel, so little have they changed with the lapse of time. So slightly divergent are these lines, considered as lines of differentiation, that, if we bound them all by two imaginary straight lines, we shall have an evolutional parallax that would carry back the origin of these types to a period inconceivably remote. We must therefore conclude that their origin was, at least in some degree, saltatory; but the real conditions under which they originated must probably always remain obscure. I have, however, elsewhere† suggested that the differentiation of the Unionidæ took place under the influence of salt in the water in which they lived; but it is plain that this explanation will not apply to the case of the palustral and land Mollusca.—*Amer. Journ. Sci.*, July 1880, pp. 44–49.

* This subject is discussed at some length in Bull. U.S. Geol. Surv. Terr. vol. iii. p. 615.

† Bull. U. S. Geol. Surv. Terr. vol. iii. p. 623.